# Natural Gas Vehicle Technology Forums

**September 9-10, 2003 Albany, NY**

**August 2-4, 2005 Washington, DC**

## "MAXIMIZING ENVIRONMENTAL BENEFITS – A REALISTIC EVOLUTION"

**Acrion Technologies, Inc. and Mack Trucks, Inc. Joint Venture**

**SSF – Success So Far**

**•Significant Technical, Economic and Organizational Milestones at**

**•State of NJ/Rutgers University EcoComplex and Burlington County Resource Recovery Center**

**•Project Accomplishment:**

**Raw LFG as Renewable Energy Source for LNG for Transportation Fuel Used by Refuse Trucks, Buses and Other LNG/CNG Vehicles**


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# LANDFILL GAS (LFG) AS A SOURCE OF LIQUEFIED NATURAL GAS (LNG) FOR TRANSPORTATION FUEL USED BY REFUSE TRUCKS, BUSES AND OTHER LNG/CNG VEHICLES

**DOE Contract 86203**
**June 11, 2005**


MACK TRUCKS, INC.
LNG/CNG ENGINE TRUCKS

AND

ACRION TECHNOLOGIES, INC.
$CO_2$ WASH™ TECHNOLOGY

# LANDFILL GAS [LFG] AS A SOURCE OF LIQUEFIED NATURAL GAS [LNG] FOR TRANSPORTATION FUEL USED BY REFUSE TRUCKS, BUSES AND OTHER LNG/CNG VEHICLES

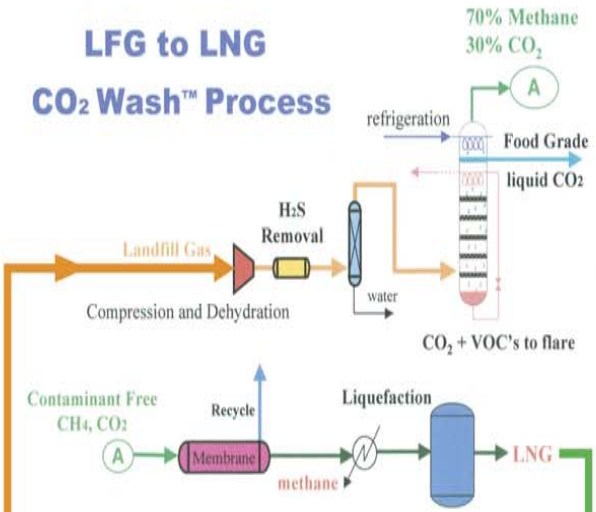
**MACK TRUCKS, INC. [LNG/CNG ENGINE TRUCKS]** AND **ACRION TECHNOLOGIES, INC. [$CO_2$ WASH™ TECHNOLOGY]**

RESIDENTIAL & COMMERCIAL REFUSE [Municipal Solid Waste]


**LANDFILL**

**LNG FUELING STATION with PURIFIED and LIQUEFIED METHANE (LFG → LNG)**

## LFG to LNG
## $CO_2$ Wash™ Process




## RESULTS ACHIEVED

### Burlington LNG Production

* Raw LFG Processed - 100 cfm
* Methane Liquefied - 350 gallon/day
* Production to Date ~ 10,000 gallons LM (LNG)
* Truck Service > 600 hours each on two WM Refuse Trucks

### Project Team

* Waste Management - refuse trucks/routes
* Acrion - LFG cleanup technology
* Mack - project management, engineering analysis, maintenance
* Chart Industries - LNG fueling station
* Air Products - LIN refrigeration
* Rutgers EcoComplex - infrastructure
* DOE Brookhaven - supplemental funding

## NEXT STEP

* Coupling Federal Energy Incentives with State Initiatives

**GOALS:**
**Strengthening US Economic and Energy Security and Achieving Significant Environmental Benefits in EPA Non-Attainment Areas**

### LFG to LNG
### Example of a Full-Scale Project

| | |
|---|---|
| Raw LFG Processed | 1,000 scfm |
| Liquid Methane | 9,700 GPD |
| Diesel Equivalent | 5,190 GPD |
| Trucks 100 LNG GPD | 100 |
| Liquid $CO_2$ | 33 TPD |
| Power | 1,400 kW |

[Preliminary design/economics are favorable]

# Table 5: 600-hour route summary for LNG 1 (Fort Dix) and LNG 2 (McGuire AFB)

| LNG 1 | Fort Dix | | | |
|---|---|---|---|---|
| **Date** | **Tot Hours** | **Tot Miles** | **Tot Stops** | **Tot Lifts** |
| Oct-04 | 93 | 834 | 1114 | 1357 |
| Nov-04 | 188 | 1750 | 2457 | 2970 |
| Dec-04 | 124 | 1129 | 1650 | 1988 |
| Jan-05 | 31 | 320 | 430 | 514 |
| **Totals** | **567** | **4033** | **5651** | **6829** |

| Average Values | | |
|---|---|---|
| Speed | 8.71 | mph |
| Gal/Hr | 9.28 | gph |
| Gal daily | 84 | gpd |
| Daily hour | 9.3 | hrs |

| Cumulative Totals | | |
|---|---|---|
| Fuel | 4,945 | gal |
| Odometer | 4,937 | miles |
| Hours | 567 | hours |

| LNG 2 | McGuire | | | |
|---|---|---|---|---|
| **Date** | **Tot Hours** | **Tot Miles** | **Tot Stops** | **Tot Lifts** |
| Oct-04 | 72 | 530 | 720 | 830 |
| Nov-04 | 178 | 1628 | 1623 | 1892 |
| Dec-04 | 105 | 1029 | 871 | 1000 |
| Jan-05 | 84.7 | 1031.9 | 655 | 789 |
| **Totals** | **596** | **4219** | **3869** | **4511** |

| Average Values | | |
|---|---|---|
| Speed | 9.17 | mph |
| Gal/Hr | 5.83 | gph |
| Gal daily | 58 | gpd |
| Daily hour | 9.5 | hrs |

| Cumulative Totals | | |
|---|---|---|
| Fuel | 3,462 | gal |
| Odometer | 5,465 | miles |
| Hours | 596 | hours |

As Table 5 shows, LNG 1 used 43% more fuel over LNG 2, however, that may be explained by the difference in total stops and lifts that LNG 1 performed as compared to LNG 2. LNG 1 had 46% more total stops and 51% more total lifts than LNG 2. Both vehicles accumulated approximately the same total mileage.

# CONCLUSION

**There was no evidence of premature wear, performance degradation, or the presence of compounds that could adversely affect engine operation, durability or reliability.**

**LFG typically contains siloxanes that form silicates when burned in the combustion chamber that will form a hard silicate plating on exhaust components. The silicates will accelerate engine wear if not removed from the LFG. Chlorinated hydrocarbons are also typically found in LFG that form acids and can attack engine bearings and were not found during the oil sampling.**

**The durability test using methane processed with the Acrion system from LFG was only scheduled to run for 600 hours. Inspections occurred at 300 and 600 hours to determine if deposits were forming that would cause premature engine wear. It is realized that 600 hours is a small snapshot of the total time the vehicle will be in service. However, based on the elemental analysis, and the valve wear measurements, there does not appear to be compounds forming, such as siloxanes, that will cause premature engine wear over the life of the engine/vehicle. The deposits seen on the cylinder heads and pistons are consistent with other E7G engines seen in the field as demonstrated by the comparison elemental analysis with the exhaust valves taken from a unit with high hours running on LNG from pipeline gas.**